Utility of a novel radiological score in predicting Haemodynamic instability in Large Pulmonary Embolism. A comparison with simplified PESI score

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Contents

Introduction

- Pulmonary Embolism's (PE's) are associated with a notable risk of morbidity and mortality. CT pulmonary angiograms (CTPA) are used in the diagnosis of pulmonary embolism and also to determine the clot burden and right ventricular strain.
- At present, there is no true standardised system to determine whether a PE will cause haemodynamic compromise / cardiopulmonary compromise.

Introduction

- A novel scoring system using radiological imaging (images from CTPA scan) was created to predict the risk of cardiopulmonary compromise.
- The first scoring system that was created was called “University Hospital of the North Midlands Score” (UHNM score) and the second scoring system was called “University Hospital of the North Midlands 2 score” (UHNM2 score).
- These scores assess the location of the clot (L) in major pulmonary arteries (scores 1, 2 and 4), the degree of occlusion (O) (score 1,2 and 3) and the impact on the right ventricle (RVR) (scores 1,2 and 3). Interventricular septum morphology (S) is also assessed (scores 1, 2, 3 and 4).

- To truly determine the effectiveness of the s-PESI, UHNM score and UHNM 2 score, a study was conducted to compare Cardiopulmonary compromise to each of these scoring systems.

Scoring systems: s-PESI

- The Simplified Pulmonary Embolism Severity Indicator (s-PESI) uses six variables
  - age of patient above 80,
  - history of cancer,
  - history of cardiopulmonary disease,
  - heart rate above 110,
  - systolic blood pressure below 100 mmHg
  - oxygen saturation below 90% at presentation,
- Used to assess the 30-day mortality of patients presenting with PE.
- The range of values varies from 0-6. Any patient with a score of 1 or above is deemed high risk. Patients deemed high risk are associated with an 8.9% 30-day mortality rate[1].

Scoring systems: UHNM scoring system

- The UHNM scoring system involves using a CTPA; to identify the percentage occlusion in the different pulmonary arteries and the morphological changes in the heart caused by a PE. After attaining these values, the UHNM scores then quantifies the risk of hemodynamic instability.

- The UHNM score is as follows: $[(L_L \times O_L) + (L_R \times O_R)] \times RVR + S$

- To calculate the score, identify the most proximal location at the clot in both left and right pulmonary arteries (L_L and L_R) then calculate the percentage occlusion of the (O_L and O_R) vessel. Now identify the Right Ventricle to Left Ventricle ratio (RVR) and the shape of the septum. Using coded values from table 1 (the UHNM score variable table); substitute these values into the equation to get the final score.

Scoring systems: UHNM scoring system

- The UHNM score is as follows: $[(L_L \times O_L) + (L_R \times O_R)] \times RVR + S$

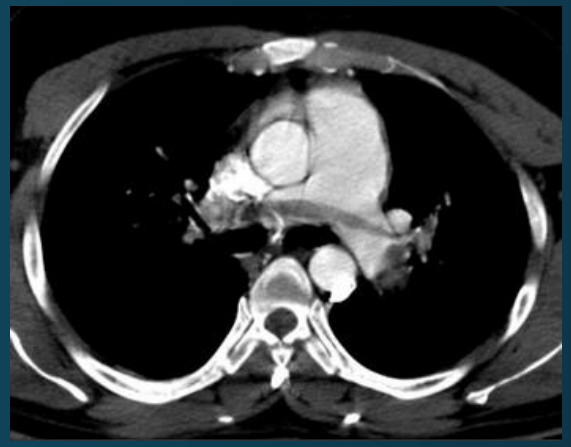
UHNM score variables				
Score	**L_L & L_R**	**O_L & O_R**	**RVR**	**S**
0	No Clot	<50%	-	-
1	LULA, LLLA, RULA, RLLA	50 - 74.99· %	<1	Concave
2	LMPA, RMPA	75 - 89.99· %	1 - 1.499·	Straight
3	-	90-100%	1.5 ≥	Sigmoid
4	MPA	-	-	Convex

Scoring systems: UHNM scoring system

Steps to calculate the UHNM score

1) Location of the PE:

- Identify the most proximal location at the clot in both left and right pulmonary arteries (the L_L and L_R in the equation). The location gives the clot gives a multiplier score:
  - Main Pulmonary Artery (MPA)= 4,
  - Left Main Pulmonary Artery (LMPA) /Right Main Pulmonary Artery (RMPA) =2,
  - Left Upper Lobar Artery, Left Lower Lobar Artery, Right Upper Lobar Artery, Right Lower Lobar Artery (LULA, LLLA, RULA, RLLA) =1.



Saddle PE effecting RMPA, MPA and LMPA
https://radiopaedia.org/articles/pulmonary-embolism?lang=gb

PE effecting RMPA and LMPA
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Scoring systems: UHNM scoring system

Steps to calculate the UHNM score

2) Percentage Obstruction by the PE:

- Calculate the percentage occlusion (O_L and O_R) of the PE in left and right Pulmonary arteries by dividing the maximum width of the PE by maximum width of the effected artery. The percentage obstruction gives the following multiplier score:
  - under 50% obstruction = 0
  - 50 to 74.99· % obstruction =1
  - 75 - 89.99· % obstruction = 2
  - 90-100% obstruction= 3

Scoring systems: UHNM scoring system

Steps to calculate the UHNM score

3) $([L_L \times O_L) + (L_R \times O_R)]$:

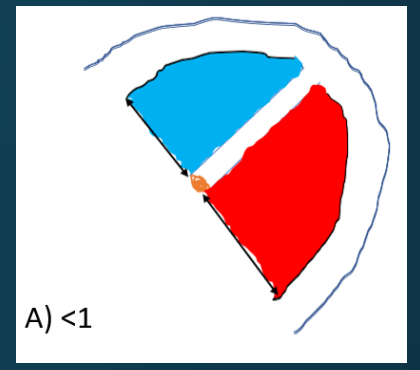
- Multiply the clot location score and percentage obstruction score for the left and right side then add the totals together
    - In cases where there is a PE in LMPA/ RMPA as well their respective lobular branches, the highest score is used e.g. use the sum total of the lobular branches if it is greater than respective main artery score.

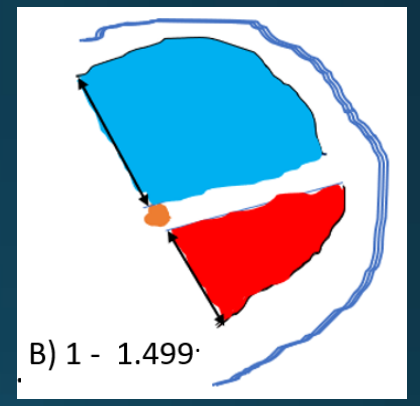
Scoring systems: UHNM scoring system

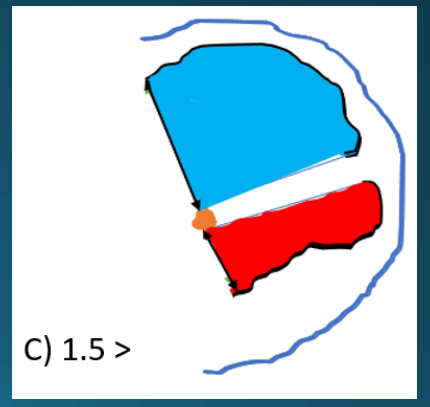
Steps to calculate the UHNM score

4) Right Ventricular to Left Ventricular size ratio (RVR):

- At the level of where the tricuspid valve is at is widest on the CTPA scan, measure the distance from the ventricular wall to the intraventricular septum for both RV and LV. RVR categories that gives the following multiplier score:
  - <1 = 1
  - 1 - 1.499· = 2
  - 1.5 ≥ = 3
- Multiply the RVR score to the subtotal of ($[L_L \times O_L) + (L_R \times O_R)]$





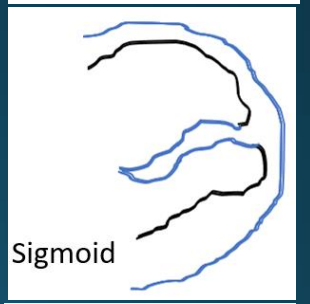


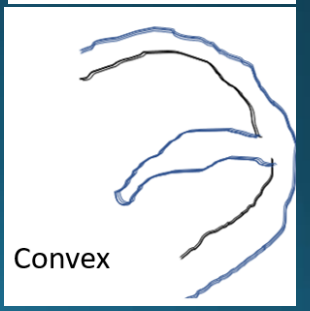
Scoring systems: UHNM scoring system

Steps to calculate the UHNM score

5) Septal score (S):

- Finally, look at the shape of the septum on CTPA. The septal score (S) is scored to septum morphology[2] :
  - Concave = 1
  - Straight =2
  - Sigmoid = 3
  - Convex = 4
- The septal score is added to the subtotal to give the final score $[(L_L \times O_L) + (L_R \times O_R)] \times RVR + S)$





Scoring systems: UHNM scoring system

UHNM Score classification

- The PE severity is classified in the UHNM score into mild (1-9), moderate (10-14) and severe 15-76.
- Patients in the moderate and high-risk group have a significantly raised risk of hemodynamic instability (greater in high risk group).
- The UHNM score provides a subtotal score from the PE and the risk of haemodynamic compromise.

Scoring systems: UHNM2 scoring system

- The UHNM2 score is an evolution of the original UHNM score, but still requiring a CTPA to calculate.

- The formula for the equation is ([LL x OL)+(LR x OR)] x [1 +(ciMPA)]) + (RVR x S).

- The UHNM 2 score has 2 distinct parts to the equation,
  - Vascular Clot Burden: ([LL x OL) + (LR x OR)] x [1 + (ciMPA)])
  - Ventricular Strain burden: (RVR x S)

- Scores ranging from 1-36

Scoring systems: UHNM2 scoring system

- The formula for the equation is ([LL x OL)+(LR x OR)] x [1 +(ciMPA)]) + (RVR x S).

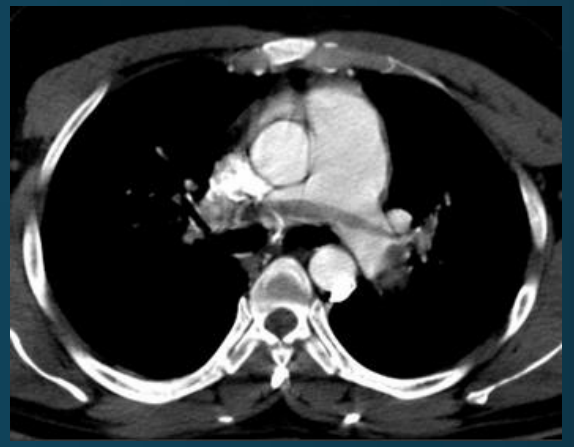
UHNM2 score variables					
Score	**L_L & L_R**	**O_L & O_R**	**ciMPA**	**RVR**	**S**
0	No Clot	<50%	No	-	-
1	LULA, LLLA, RULA, RLLA	50 - 74.99. %	Yes	<1	Concave
2	LMPA, RMPA	75 - 89.99. %	-	1 - 1.499.	Straight
3	-	90-100%	-	1.5 ≥	Sigmoid
4	-	-	-	-	Convex

Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: vascular clot burden

1) Location of the PE:

- Identify the most proximal location at the clot in both left and right pulmonary arteries (the L_L and L_R in the equation). The location gives the clot gives a multiplier score:
  - Left Main Pulmonary Artery (LMPA) /Right Main Pulmonary Artery (RMPA) =2,
  - Left Upper Lobar Artery, Left Lower Lobar Artery, Right Upper Lobar Artery, Right Lower Lobar Artery (LULA, LLLA, RULA, RLLA) =1.



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Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: vascular clot burden

2) Percentage Obstruction by the PE:

- Calculate the percentage occlusion (O_L and O_R) of the PE in left and right Pulmonary arteries by dividing the maximum width of the PE by maximum width of the effected artery. The percentage obstruction gives the following multiplier score:
  - under 50% obstruction = 0
  - 50 to 74.99· % obstruction =1
  - 75 - 89.99· % obstruction = 2
  - 90-100% obstruction= 3

Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: vascular clot burden

3) $([L_L \times O_L) + (L_R \times O_R)]$:

- Multiply the clot location score and percentage obstruction score for the left and right side then add the totals together
    - In cases where there is a PE in LMPA/ RMPA as well their respective lobular branches, the highest score is used e.g. use the sum total of the lobular branches if it is greater than respective main artery score.

Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: vascular clot burden

4) Identify if there is MPA PE:

- This section to identify if there MPA embolus present, such MPA saddle PE, which is coded as “clot in the Main Pulmonary Artery” (ciMPA). This allows clot burden to incorporate the burden of MPA embolus. If there is MPA PE, it coded for ciMPA score as follows:
  - No MPA PE =0
  - MPA PE = 1

Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: vascular clot burden

5) Vascular Clot burden:

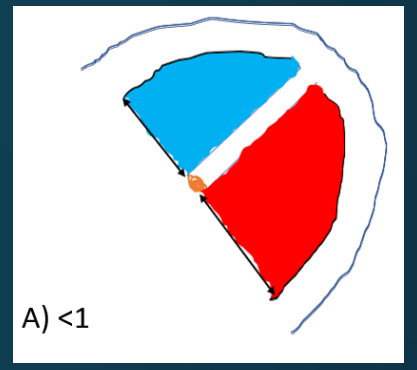
- The (1+ ciMPA) total is multiplied total from step 3, $([L_L \times O_L) + (L_R \times O_R)]$ to get the vascular clot burden (score ranges from 0 to 24)

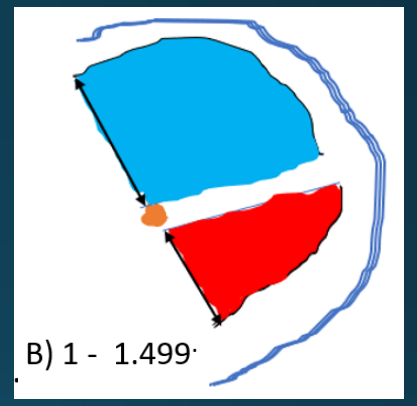
Scoring systems: UHNM2 scoring system

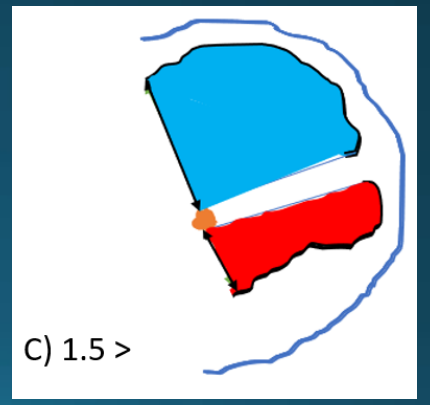
Steps to calculate the UHNM2 score: Ventricular strain score

6) Right Ventricular to Left Ventricular size ratio (RVR):

- At the level of where the tricuspid valve is at is widest on the CTPA scan, measure the distance from the ventricular wall to the intraventricular septum for both RV and LV. RVR categories that gives the following multiplier score:
  - <1 = 1
  - 1 - 1.499· = 2
  - 1.5 ≥ = 3





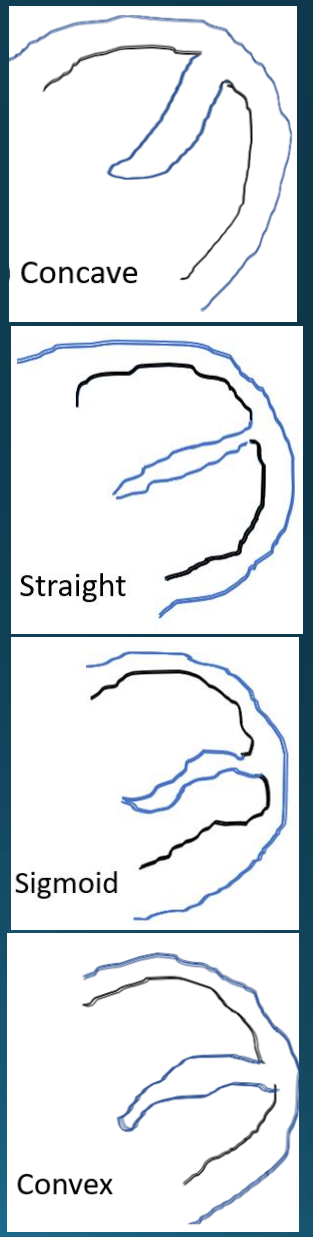


Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: Ventricular strain score

7) Septal score (S):

- Finally, look at the shape of the septum on CTPA. The septal score (S) is scored to septum morphology:
  - Concave = 1
  - Straight =2
  - Sigmoid = 3
  - Convex = 4



Scoring systems: UHNM2 scoring system

Steps to calculate the UHNM2 score: Ventricular strain score

8) Ventricular strain:

- Multiply the RVR score by the Septal Score to get the ventricular strain (RVR x S)

9) UHNM 2 score:

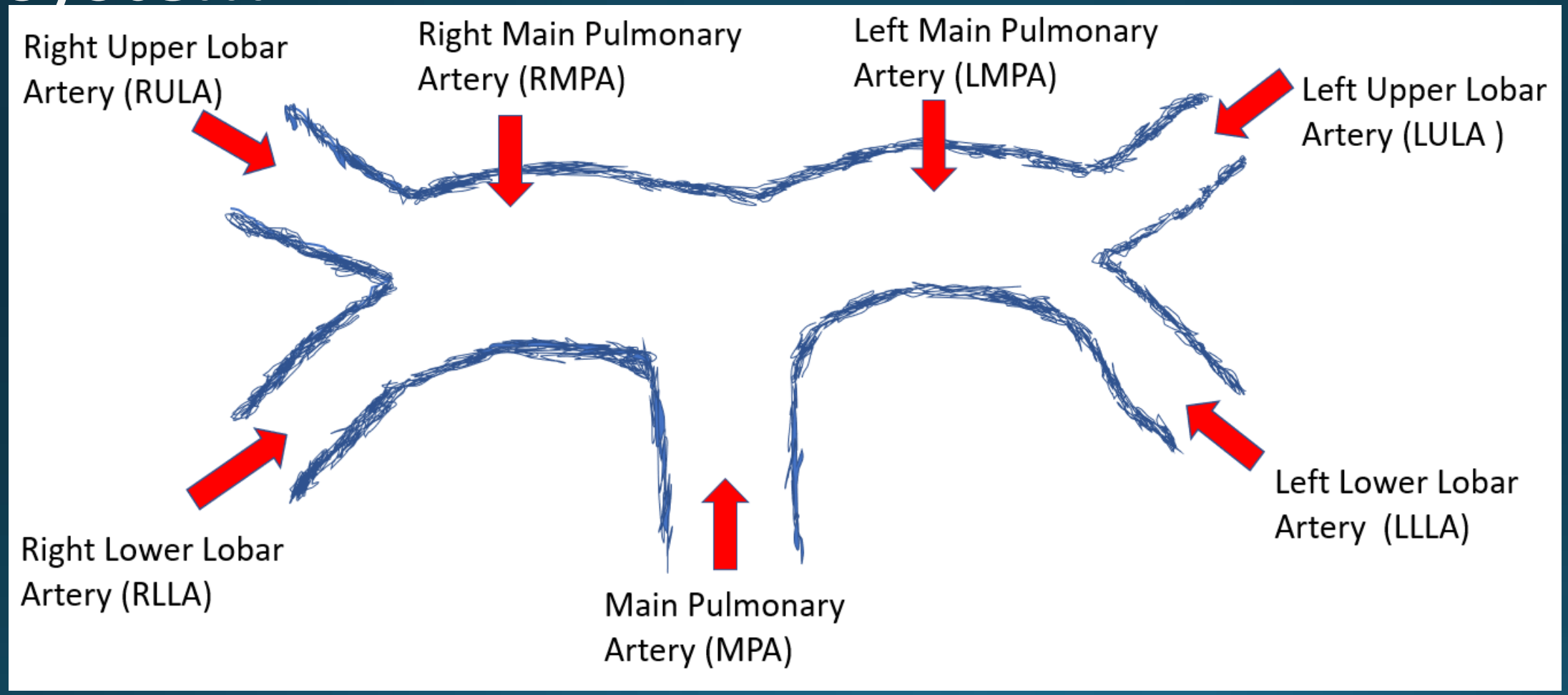
- UHNM2 Score :
  - $=([L_L \times O_L)+(L_R \times O_R)] \times [1 +(ciMPA)]) + (RVR \times S)$
  - = Vascular clot Burden score + Ventricular strain score

Scoring systems: UHNM2 scoring system

UHNM2 Score classification

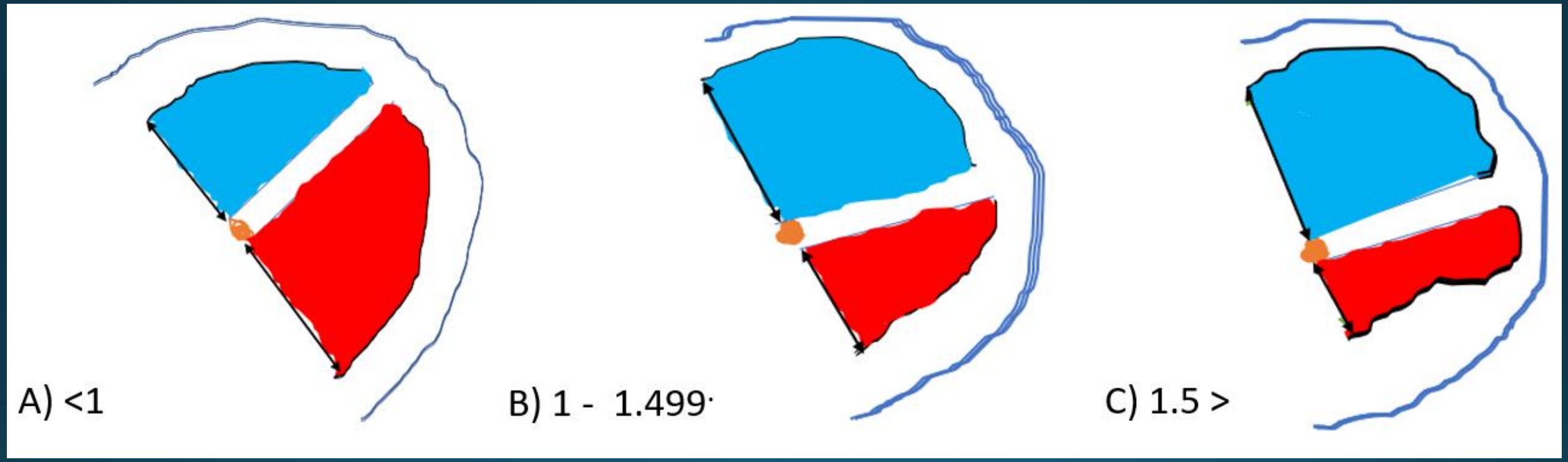
- The PE severity is classified in the UHNM score into mild (1-9), moderate (10-14) and severe 15-76.
- Patients in the moderate and high-risk group have a significantly raised risk of hemodynamic instability (greater in high risk group).
- The UHNM score provides a subtotal score from the PE and the risk of haemodynamic compromise.

Scoring systems: UHNM & UHNM 2 scoring system



- Image 1: A simple diagrammatic representation main pulmonary arteries

Scoring systems: UHNM & UHNM2 scoring system



- Figure 2: The image shows the different RVR Ratio categories

Scoring systems: UHNM & UHNM2 scoring system

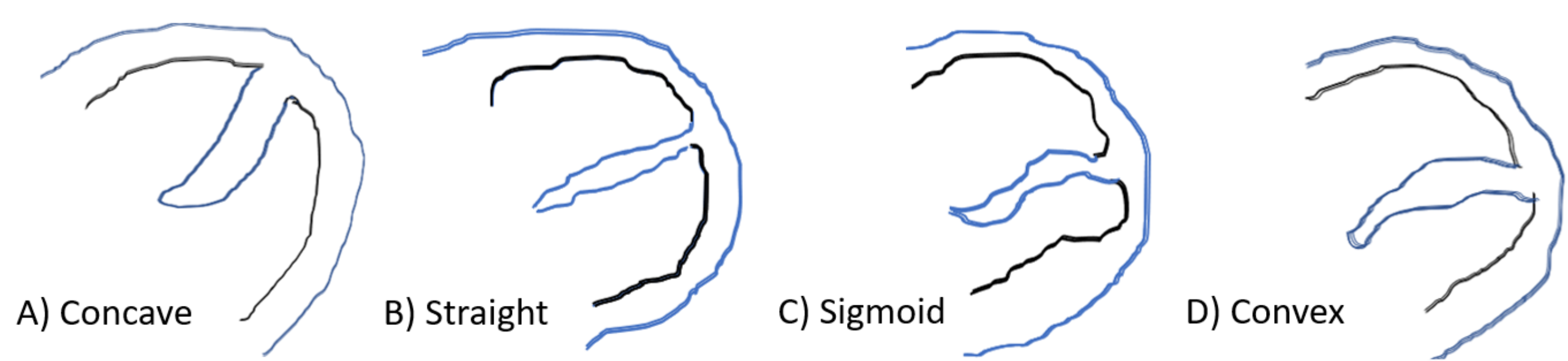


Figure 3: The image shows the different interventricular septal shapes

Methods of study

- A retrospective study was made of 485 patients who were diagnosed with PE's in University Hospital of the North Midlands, over the period of March 2014 to July 2018. From the electronic database and the PACS system, clinical data was obtained along with CTPA images, so patients could be scored with the novel scoring system
- This study compares patients classified as low vs moderate/high risk by the s-PESI, UHNM and UHNM2 scores to which patients had Haemodynamic instability (in-patient Cardiothoracic referral, in-patient CPR, in-patient thrombolysis for PE management and emergency embolectomy) due to their PE's.

Methods of study: Inclusion and Exclusion criteria

Inclusion Criteria:

- The patient must have a CT confirmed PE, which can be viewed in the PACS system

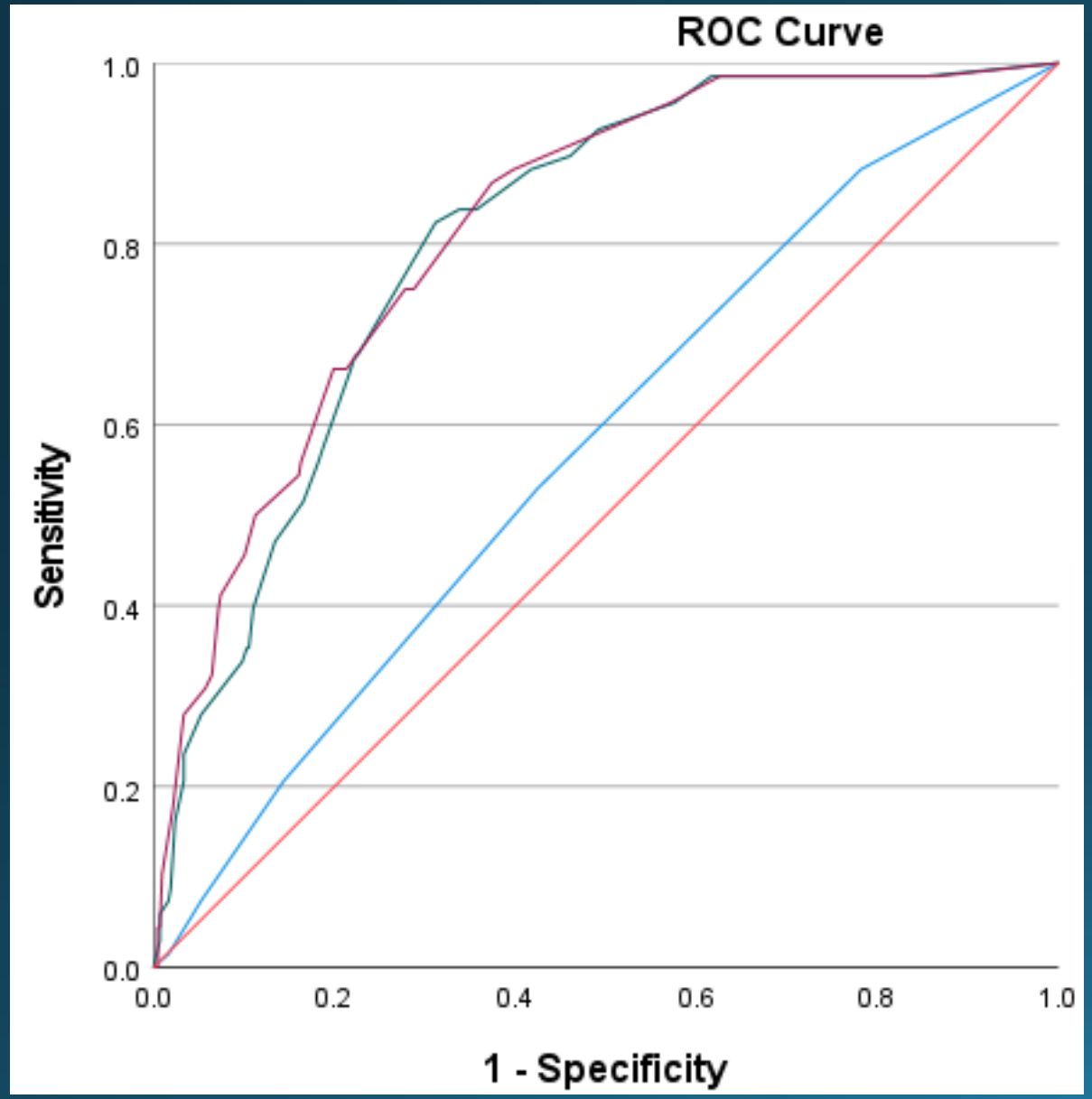
Exclusion Criteria:

- Patients do not have a PE in the Main Pulmonary artery (MPA), Left Main Pulmonary artery (LMPA) or Right Main Pulmonary artery (RMPA),
- Patient with no records in the electronic system or on PACS.

Methods of study: statistical analysis

- The Statistical analysis allowed:
  - Receiver operating characteristic curves (AUROC) to be created to measure the predictive power of each scoring system.
  - Multivariant logistical analysis to calculate Adjusted Odds Ratio (AOR) with 95% Confidence intervals

Results: AUROC analysis



AUROC analysis of Haemodynamic instability caused by PE's

Results: AUROC analysis

Scoring system	Cut Off score	Sensitivity	Specificity	PPV	AUROC	95% Confidence Interval (95% CI)	SE [a]	p Value [b]
s-PESI	0	88.24%	21.82%	15.54%	0.575	0.504 - 0.646	0.36	0.047
UHNM	9	88.26%	58.27%	25.64 %	0.807	0.758 - 0856	0.25	0.000
UHNM 2	7	92.65 %	49.88%	23.16%	0.818	0.769 - 0.867	0.25	0.000

a. Standard Error under the nonparametric assumption

b. Null hypothesis: No difference between positive and negative result, true area = 0.5

Abbreviation:

- PPV= Positive Predictive value

Results: Adjusted odds ratio for UHNM score

Variants	Haemodynamic instability AOR (95% CI)
Age	0.985 (0.966 - 1.005)
Cancer Hx	0.991 (0.457 - 2.152)
CPD Hx	1.042 (0.534 - 2.034)
HR > 110	1.349 (0.712 - 2.555)
SBP<100mmHg	2.281 (1.002 - 5.189)
O2<90%	1.288 (0.611 - 2.717)
Other AIPI	0.766 (0. .372 - 1.578)
UHNM	12.197 (4.670 - 31.853)

Retrospective multivariant analysis for patients with Moderate to High UHNM score PE's.

Abbreviations

- Cancer Hx: history of cancer
- CPD Hx: cardiopulmonary disease history
- HR > 110: heart rate above 110,
- SBP<100mmHg: systolic blood pressure below 100 mmHg
- O2<90%: oxygen saturation below 90%
- Other AIPI: Other acute In-Patient Issue along with PE
- UHNM: Moderate to high score in UHNM score

Results: Adjusted odds ratio for UHNM2 score

Variants	Haemodynamic instability AOR (95% CI)
Age	0.985 (0.966 - 1.005)
Cancer Hx	0.948 (0.444 - 2.024)
CPD Hx	1.136 (0.587 - 2.198)
HR > 110	1.383 (0.734 - 2.607)
SBP<100mmHg	1.940 (0.872 - 4.318)
O2<90%	1.371 (0.655 - 2.868)
Other AIPI	0.772 (0.381 - 1.562)
UHNM	14.598 (4.408 - 48.349)

Retrospective multivariant analysis for patients with Moderate to High UHNM2 score PE's.

Abbreviations

- Cancer Hx: history of cancer
- CPD Hx: cardiopulmonary disease history
- HR > 110: heart rate above 110,
- SBP<100mmHg: systolic blood pressure below 100 mmHg
- O2<90%: oxygen saturation below 90%
- Other AIPI: Other acute In-Patient Issue along with PE
- UHNM2: Moderate to high score in UHNM2 score

Discussion

AUROC analysis

- UHNM & UHNM 2 were statically superior scoring system to s-PESI at predicting haemodynamic instability caused by PE's.
- Though UHNM 2 has a greater AUROC to UHNM, it was not statically superior.
- AUROC value for haemodynamic instability for UHNM and UHNM 2 scores are above 0.8, therefore is a good predictive scoring system.
- Low standard error indicates AUROC values for each scoring system are accurate values

Discussion

AUROC analysis

- Clinician bias should be noted, as escalation plans can be limited for PE's depending on age and co-morbidities.
  - Despite having large UHNM/ UHNM 2 scores, some patients were not given further management (aside from treatment dose LMWH) and had DNACPR due to their co-morbidities. Therefore the true predictive values for UHNM and UHNM 2 score could have been higher.

Discussion

Multivariant analysis of Adjusted Odds Ratio's (AOR)

- Moderate to high UHNM and UHM2 scores are independent predictor of haemodynamic instability
- SBP< 100mmHg was an independent predictor for haemodynamic instability when using UHNM.
  - Low Systolic Blood Pressure (SBP) is linked to ventricular compromise, and therefore linked to Moderate to high UHNM and UHNM2 score.
  - Moderate to high UHNM2 scores are slightly stronger predictive factor than respective UHNM scores, for haemodynamic instability (but not statically more significant). Therefore it reduced Adjusted Odds ratio of all other factors making SBP< 100mmHg a non significant risk factor.

Discussion

Multivariant analysis of Adjusted Odds Ratio's (AOR)

- If using UHNM2 score rather than UHNM score:
  - Moderate to high UHNM 2 scores are the only independent variable that predicts haemodynamic instability (from this study).

Limitations of the study

- Assumes all patients are full association of care and no clinician bias
- Individual interpretations of CT scans can vary (of level of obstruction, RVR, septal shape)
- Looking at 2-D slices while clots are 3-D
- Assumes normal anatomy
- RVR maybe inaccurate if existing Pulmonary HTN, RVH, LVH, dilated ventricles.

Conclusion

- UHNM and UHNM2 scoring systems are good diagnostic tests to predict haemodynamic instability caused by a Pulmonary Embolus (as per AUROC analysis)
- UHNM 2 scoring system has a greater AUROC value to UHNM score; though it was not statically superior.

- If UHNM score is used: Systolic Blood Pressure below 100 mmHg and Moderate to high UHNM scores are the independent variables that predict haemodynamic instability (from this study).

- If UHNM2 score is used: Moderate to high UHNM 2 scores are the only independent variable that predicts haemodynamic instability (from this study).

Thank you for time

Reference

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